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An Allowance for Bark Increment in Computing Tree Diameter Growth for Southeastern Species

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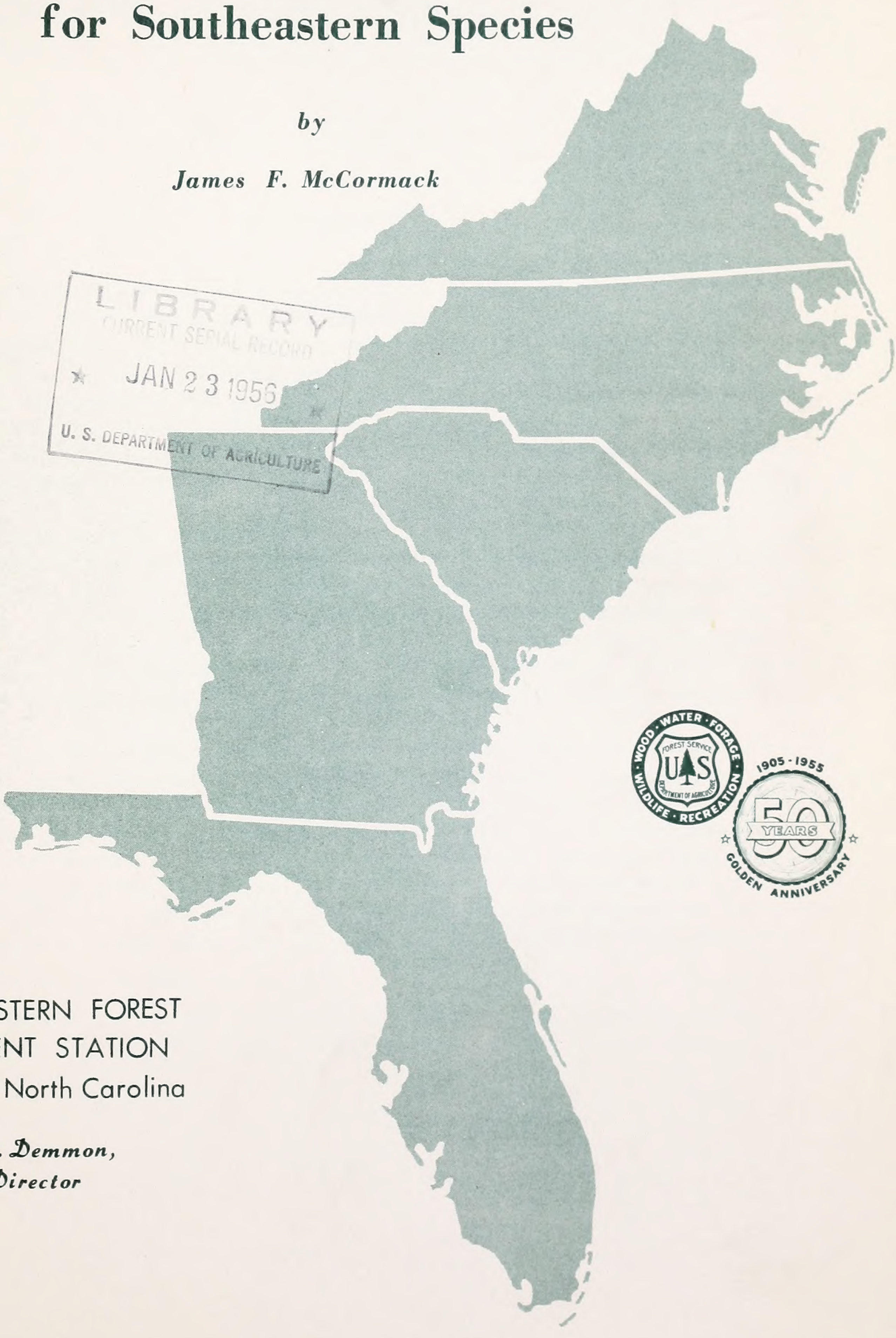

SOUTHEASTERN FOREST
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AN ALLOWANCE FOR BARK INCREMENT IN COMPUTING TREE DIAMETER GROWTH FOR SOUTHEASTERN SPECIES

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James F. McCormack

INTRODUCTION

Foresters concerned with estimates of timber volume growth on any area or tract must first of all determine the rate of increase in tree size. The most important measurement, and often the only one made, is of the change in tree diameter at breast height over a specified period of years. Increment cores taken at this point 4.5 feet above ground are commonly used to measure the combined radial growth of a number of annual rings. This method provides data on the rate of wood growth, but it is impractical for measuring changes in bark, which slowly increases in thickness over the years.

Tables giving the volume of wood in a tree are customarily based on measurement of tree diameter outside bark. In growth computations, therefore, the usual problem is to find the outside-bark diameter, and thus the volume, of sample trees at the beginning of a growth period. Where no allowance is made for bark growth and the past tree diameter is obtained by subtraction of wood growth alone, an underestimate of the actual increase in diameter ranging up to 17 percent may be introduced into the computations.

The purpose of this paper is to describe a method of taking the change in bark thickness into account, and also to present a set of growth factors suitable for use with southeastern species. The method used here is an adaptation of the procedure published by Meyer[1/] in 1942 for the determination of diameter increment. The growth factors are constants developed from field data which serve a dual purpose. They provide the needed allowance for bark growth by individual species, and they also convert radial growth, as measured on the increment core, directly to diameter growth including wood and bark.

1/ Meyer, H. Arthur. Methods of forest growth determination. Bulletin 435, Pennsylvania State College, School of Agriculture, 93 pp., illus. December 1942.

THE SAMPLE DATA

Bark thickness has been measured on thousands of sample trees in the Southeast by the Forest Survey for use in growth estimates. Sample trees were selected on ground plots under a strict area basis according to tree size so they would be representative of average timber stands. Field crews using the Swedish bark gauge measured the radial thickness of bark to the nearest 5 one-hundredths of an inch. This measurement was made at breast height on trees of normal form. It was always made on the plot-center side of the sample tree except on pronounced slopes, where the measurement was made on the uphill side. On swell-butted species such as cypress and tupelo gum growing in swampy areas, the measurements of both tree diameter and bark thickness were made at a point called "bottleneck," which is 18 inches above the top of the pronounced swell. Single bark thickness was doubled to obtain total thickness of bark in tenths of an inch. This value was subtracted from the outside-bark diameter of the tree, as measured with a diameter tape, to obtain inside-bark diameter.

Most of the bark data used in developing the growth factors were collected on sample plots in Virginia, South Carolina, Georgia, and Florida. Some additional data were obtained from a number of other studies in southeastern states where bark measurements had been made. The data, identified by source, species, and tree size, were punched in IBM cards for summary and analysis.

RATIO OF OUTSIDE TO INSIDE BARK DIAMETER

The relationship of diameter outside bark (d.o.b.) to diameter inside bark (d.i.b.) was used to derive the growth factors. The data were separated by species, and the measurements in inches and tenths were summed up by 2-inch diameter classes. Average values for diameter outside and inside bark were then computed for each class and plotted on coordinate paper as shown in figure 1. This relationship is linear and may be adequately represented by a straight line drawn through the plotted points. Such a line was fitted to the data for each species by the method of least squares. The degree of correlation between the two diameter measurements is obviously very high.

The regression equation $Y = a + bX$ was used in fitting the lines to d.o.b. plotted over d.i.b. For loblolly pine, the expression turned out to be d.o.b. = .703 + (1.095)d.i.b. The regression coefficient 1.095 gives the slope or rate at which the line is rising. In other words, it is a ratio which shows the change in outside-bark diameter per unit of change in inside-bark diameter. Thus, for loblolly, diameter outside bark increases 1.095 inches for each increase of 1 inch in diameter inside bark.

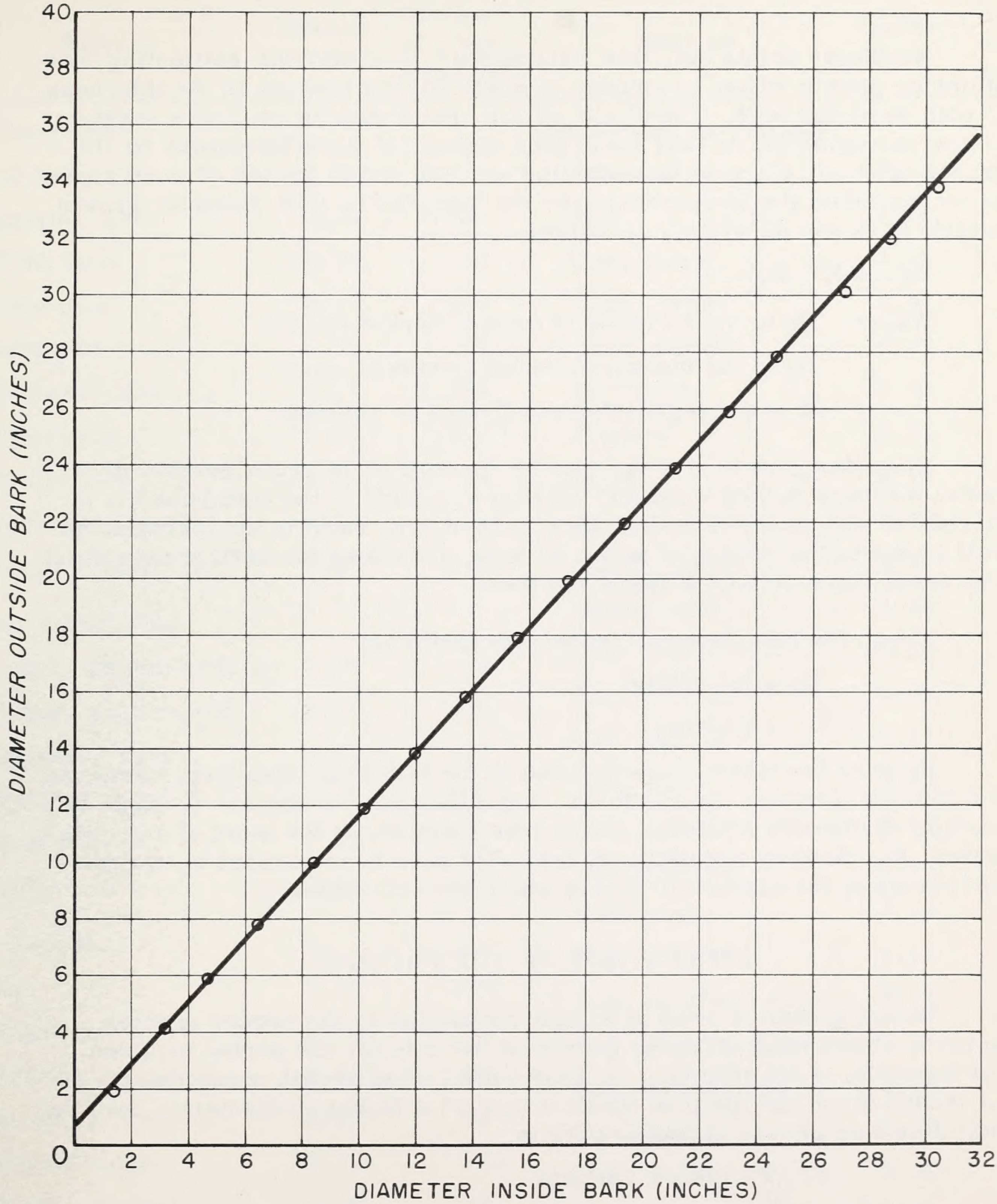

Figure 1.--Relation of diameter outside bark to diameter inside bark for loblolly pine.

COMPUTATIONS OF GROWTH FACTORS

As Meyer points out, this relationship is useful for estimating tree diameter growth which, of course, is made up of increases in the thickness of both wood and bark. The d.o.b.-d.i.b. ratio may be used as a constant in the computations to add the proper amount of bark increment to the growth of wood. Since we are starting with the radial growth of wood alone, as measured on the increment core, the formula for tree diameter growth outside bark can be written as follows:

$$Dg = 2(K \cdot Rg)$$

Where: Dg is the increase in outside bark diameter

Rg is the measured radial growth of wood

K is the regression coefficient or constant

Diameter growth of trees can be visualized in cross section as a radial increase in both wood and bark on each side of the tree bole. It is, therefore, necessary to double the d.o.b.-d.i.b. ratio in the formula, as well as the radial growth of wood, to make allowance for bark growth which also takes place on both sides of the tree.

Then, for loblolly pine, the growth factor is:

$$Dg = 2(1.095Rg)$$

$$= 2.190Rg$$

Factors for other species shown in the following table were computed in a similar manner. In this form, they minimize the amount of hand or machine arithmetic needed to obtain tree diameter at the start of a growth period. For further simplicity in use, they have been rounded to two decimal places at the expense of a very small loss of accuracy.

APPLICATION OF THE FACTORS

Radial growth of wood is simply multiplied by the proper species factor to obtain total diameter growth of the tree for the period involved. For example, if we assume a 10-year radial wood growth measurement of 1.1 inches for a loblolly pine which is now 13.2 inches in diameter, then the total diameter growth including bark is:

$$(1.1)(2.19) = 2.4 \text{ inches}$$

The outside bark diameter of the tree at the beginning of the period, obtained by subtraction, would be:

$$13.2 - 2.4 = 10.8 \text{ inches.}$$

Growth factors for southeastern species

Species	Growth factor	Number of trees sampled
Yellow pines:		
Loblolly pine	2.19	2,654
Longleaf pine	2.12	1,581
Pitch pine	2.15	93
Pond pine	2.17	258
Sand pine	2.12	57
Shortleaf pine	2.17	1,681
Slash pine	2.14	1,205
Spruce pine	2.11	54
Table Mt. pine	2.12	16
Virginia pine	2.20	742
Other softwoods:		
Cedar, Atlantic white	2.20	15
Cedar, eastern red	2.07	44
Cypress, bald	2.05	167
Cypress, pond	2.15	569
Hemlock	2.18	113
White pine	2.23	117
Hardwoods:		
Ash	2.10	249
Basswood	2.11	66
Beech	2.04	90
Birch, yellow	2.07	29
Birch, black	2.17	16
Birch, river	2.19	29
Buckeye	2.09	21
Butternut	2.14	11
Cottonwood	2.21	23
Cucumber	2.20	29
Hardwoods (continued)		
Dogwood	2.18	22
Elm	2.10	139
Gum, black	2.15	1,214
Gum, sweet	2.07	950
Gum, tupelo	2.12	105
Hackberry	2.08	33
Hickory	2.11	461
Holly	2.10	29
Locust, black	2.40	19
Maple, hard	2.07	53
Maple, soft	2.10	485
Oak, black	2.13	221
Oak, chestnut	2.18	160
Oak, laurel	2.11	317
Oak, live	2.13	59
Oak, northern red	2.15	169
Oak, overcup	2.10	41
Oak, post	2.19	120
Oak, scarlet	2.11	572
Oak, southern red	2.14	152
Oak, swamp chestnut	2.08	66
Oak, swamp red	2.14	36
Oak, water	2.10	305
Oak, white	2.16	873
Oak, willow	2.09	132
Poplar, yellow	2.18	599
Sycamore	2.09	46
Sweetbay	2.16	257
Walnut, black	2.27	27

Without the allowance for increase in bark thickness, the radial growth of wood only would be doubled, resulting in an estimated 2.2 inches of diameter growth and a past diameter of 11.0 inches for the tree. This procedure would be in error since it underestimates the actual tree diameter growth by 8 percent and, in this example, would place the tree in the wrong diameter class at the start of the growth period. An error of this type is non-compensating and will carry forward into computation of volume growth with varying effect depending on the size of the sample tree.

Although a number of factors in the table are the same, or very similar, they are shown separately for ease in use, and also because volume tables for individual species may be significantly different. In case it is desirable to use a single factor for a group of species, such as the yellow pine, a weighted factor can easily be developed by using the number of sample trees of each species in the stand as weights for the individual factors.

The sampling error of individual factors varies from about ±1 percent for a heavily sampled species such as loblolly pine to ±11 percent for black locust, which was sampled very lightly. Regression curves were also tested for geographical differences, but no significant variations were found.

These factors are now being used by the Forest Survey in growth computations, which are handled on punch card equipment. The bark thickness data obtained so far are adequate, at least for the more important species, and collection of bark measurements in the field has been discontinued. Since the factors are based on representative stand data over broad areas, they should be sufficiently accurate for general use in the Southeast.

Agriculture-Asheville